

# Higher Temperatures Were Closely Associated with Higher Ambulance Transports in Takamatsu Area, Japan

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## ABSTRACT

*The link between high temperatures and ambulance transports in Takamatsu area, Japan was investigated. Monthly observations for ambulance transports (2004-2008) were obtained from Fire Department Service in Takamatsu. Data of temperatures in Takamatsu area, Japan (2004-2008) were used by Japan Meteorological Agency. Effect of high temperatures on ambulance transports was analyzed. By using data from July to September, there were not clear differences of mean temperatures and ambulance transports among years. Ambulance transports were significantly correlated with parameters of temperatures. Correlation coefficient rate between ambulance transports and the mean temperature of maximum temperatures in a month was highest among parameters ( $r = 0.738$ ,  $p = 0.0017$ ). In addition, ambulance transports were also significantly correlated with the number of days over the level of 32°C in a month ( $r = 0.782$ ,  $p = 0.0006$ ). Higher temperatures were closely associated with higher ambulance transports in Takamatsu area, Japan.*

**Keywords:** Temperature, Ambulance Transports, Takamatsu Area, Fire Department Service in Takamatsu, Japan Meteorological Agency

## 1. Introduction

Global average temperatures are projected to increase between 1.4 and 5.8°C by the end of this century [1]. On local and regional scales, changes in land cover can sometimes exacerbate the effect of greenhouse-gas-induced warming, or even exert the largest impact on climatic conditions. Most cities show a large heat island effect, registering 5-11°C warmer than surrounding rural areas [2]. An increase in mortality related to heat waves has been reported from various industrialized countries [3-5].

The number of patients with heat stroke is surveyed by National Institute for Environmental Studies in several cities, except Takamatsu area, in Japan [6]. An increase in summer temperatures is likely to increase the number of patients with high temperatures related diseases. Therefore, it is timely to assess local evidence of acute health effects of high temperatures in Takamatsu area,

Japan.

In this study, to address this issue, we investigated monthly ambulance use and its relation to high temperatures in 5 summers in Takamatsu area, Japan.

## 2. Methods

### 2.1. Study Area

Takamatsu area, Kagawa prefecture, Japan, which includes Takamatsu city, Miki-cho and Ayagawa-cho, is on the northern shore of Shikoku Island (in a temperate zone area). The population of Kagawa prefecture is 1 000 000 and 470 000 people are situated on the Takamatsu area. Currently several public offices of Shikoku district are located in Takamatsu city. Although the surrounds of Takamatsu had been used primarily as paddy fields for agriculture, recently they have undergone rapid changes, developing into residential and/or commercial areas. The area's emergency medical services are managed by Fire

Department Service in Takamatsu and 14 ambulances were in use in 2008 [7].

## 2.2. Ambulance Data

Monthly incidence data of ambulance transports was obtained from Fire Department Service in Takamatsu from July to September for 5 years (2004-2008) [7]. We excluded the number of other ambulance transports *i.e.* traffic accidents, fire accidents and injuries, and the number of ambulance transports (per a month per ten thousand persons) by acute diseases [8] was used for analysis.

## 2.3. Temperatures

Daily and monthly temperatures in Takamatsu area, Japan for the required periods were obtained from Takamatsu Local Meteorological Observatory, Japan Meteorological Agency [9]. Mean temperature in a month, mean temperature of maximum temperatures in a month, mean temperature of minimum temperatures in a month, maximum temperature in a month, minimum temperature in a month and the number of days over the level of various temperatures in a month were used for analysis.

## 2.4. Statistical Analysis

Simple correlation analysis was used to test the significance of the linear relationship among continuous variables:  $p < 0.05$  was considered to be statistically significant.

## 3. Results

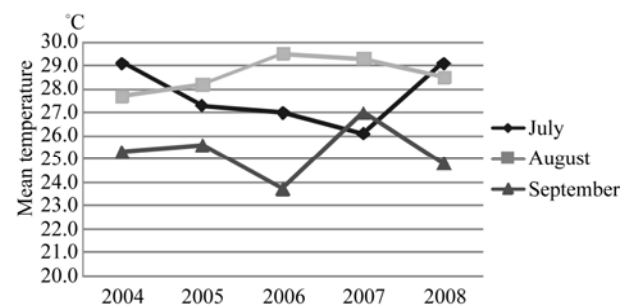
Changes in mean temperature in a month are summarized in **Figure 1**. There were not clear differences of mean temperature in a month for 5 years. There were not also clear differences of ambulance transports (per a month per ten thousand persons) for 5 years (**Figure 2**).

We investigate the relationship between ambulance transports and parameters of temperatures from July to September for 5 years (2004-2008) in Takamatsu area, Japan (**Table 1**). Ambulance transports were significantly correlated with parameters of temperatures. Correlation coefficient rate between ambulance transports and mean temperature of maximum temperatures in a month was highest among parameters ( $r = 0.738$ ,  $p = 0.0017$ ). The slope of the regression line (changes in mean temperature of maximum temperatures in a month vs changes in ambulance transports) was 0.597 (**Figure 3**). Accordingly, we found that a  $1^{\circ}\text{C}$  in mean temperature of maximum temperatures in a month corresponded to a 0.597 increase in ambulance transports (per a month per ten thousand persons) in Takamatsu area.

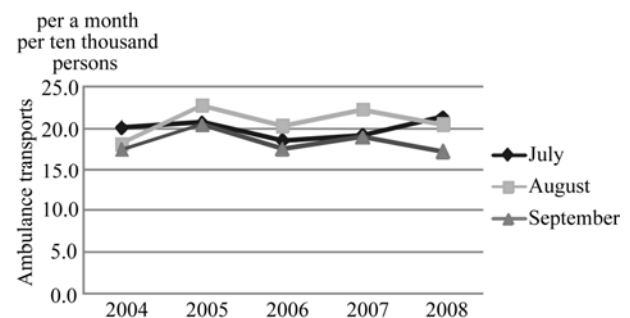
In addition, the relation between ambulance transports and the number of days of over the level of various tem-

**Table 1. Simple correlation analysis between ambulance transports and parameters of temperatures in Takamatsu area, Japan.**

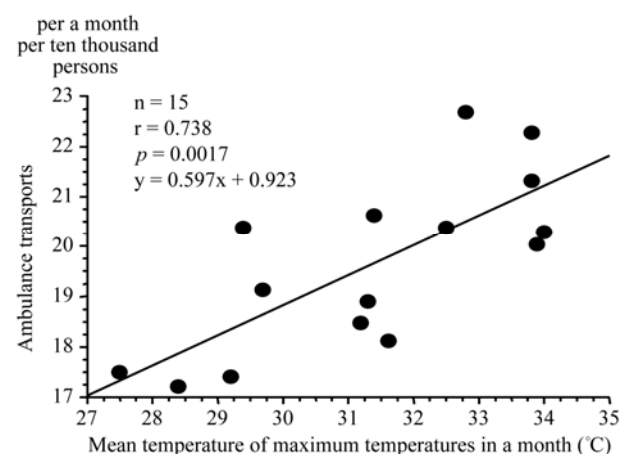
	<i>r</i>	<i>p</i>
Mean temperature in a month	0.728	<b>0.0021</b>
Mean temperature of maximum temperatures in a month	0.738	<b>0.0017</b>
Mean temperature of minimum temperatures in a month	0.668	<b>0.0065</b>
maximum temperature in a month	0.693	<b>0.0042</b>
minimum temperature in a month	0.555	<b>0.0318</b>



**Figure 1. Changes in mean temperature (2004-2008).**



**Figure 2. Changes in ambulance transports (2004-2008) (per a month per ten thousand persons).**



**Figure 3. Simple correlation analysis between ambulance transports and mean temperature in a month.**

peratures was also evaluated (Table 2). Ambulance transports were significantly correlated with the number of days of over the level of various temperatures, especially over the level of 32°C ( $r = 0.782$ ,  $p = 0.0006$ ) (Figure 4).

#### 4. Discussion

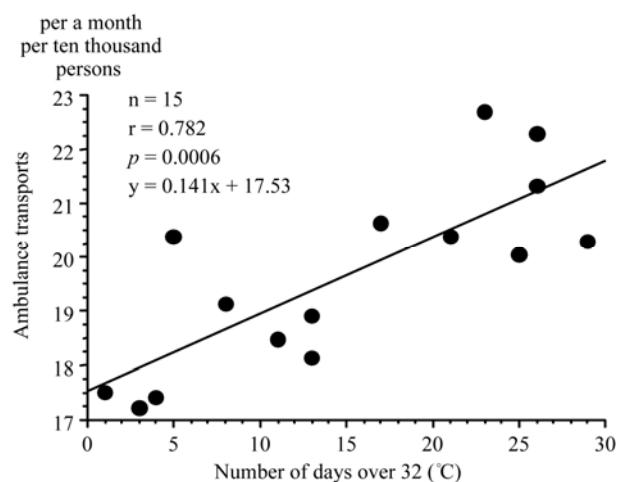
We firstly investigated the link between ambulance transports and parameters of temperatures in Takamatsu area, Japan. Ambulance transports were significantly associated with high temperatures.

In some literatures, the relation between high temperatures and heat stroke in Japan [10-12]. Nakai *et al.* investigated heat-related deaths in Japan from 1968 through 1994 and heat-related deaths were most prone to occur on days with a peak daily temperature above 38 degrees [10]. In addition, they reported that incidence of heat-related deaths showed an exponential dependence on the number of hot days [10]. Qui *et al.* reported that an unusually hot spell in 1999 was followed by a high mortality rate in Hokkaido, Japan [11]. Bai *et al.* also showed that the number of unusual deaths in the summer of 1994 in Osaka, Japan was more compared to those of previous years [12]. The human body dissipates heat in four ways: convection, conduction, radiation and water evaporation. When the temperature of the surrounding environment is higher than the body temperature, water evaporation is the only way in which the body can dissipate heat. When the air temperature is over 34 degrees, cardiovascular and nervous disorders can occur as a result of problems associated with body temperature adjustment and metabolism of water and salts [11]. Unexpectedly high temperatures are particularly difficult for the elderly [13,14], and chronic diseases [15]. In this study, we investigated the relationship between ambulance transports and parameters of temperatures, and close relationship was noted between ambulance transports and high temperatures in Takamatsu area, Japan. Although, we could not directly evaluate the heat-related diseases or deaths, it seems reasonable to suggest that simply dealing with high temperatures in summer in Takamatsu city *i.e.* innovation of the thermal energy metabolism in cities and individual coping with high temperatures might result in the amelioration of ambulance transports in Takamatsu area, Japan.

Potential limitations still remain in this study. First, the link between ambulance transports and temperatures, which was noted in this study, may not apply for the link among individuals. Second, we could not directly evaluate heat-related diseases or deaths. Third, daily data of ambulance transports could not be obtained in this study. Therefore, we could not accurately evaluate the link between ambulance transports and high temperatures. Fur-

**Table 2. Simple correlation analysis between ambulance transports and number of days over the level of various temperatures in a month.**

	$r$	$p$
Number of days over 30°C	0.682	<b>0.0051</b>
Number of days over 31°C	0.778	<b>0.0006</b>
Number of days over 32°C	0.782	<b>0.0006</b>
Number of days over 33°C	0.723	<b>0.0023</b>
Number of days over 34°C	0.677	<b>0.0056</b>
Number of days over 35°C	0.644	<b>0.0006</b>



**Figure 4. Simple correlation analysis between ambulance transports and the number of days over the level of various temperatures.**

ther studies are required to prove such link.

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